

Enhancing Problem-Solving Skills for Grade 5 Students in Teaching Ratios and Percentages: Evidence from Vietnamese Primary Education

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ABSTRACT: Mathematics education at the primary level plays a crucial role in laying the foundation for students' intellectual development and problem-solving competence. However, many Grade 5 students in Vietnam still face significant difficulties when dealing with ratio and percentage problems, especially in applying reasoning and selecting appropriate solution strategies. This study aims to explore the current situation of students' mathematical problem-solving skills and to propose pedagogical interventions that enhance their competence in this domain. Using a mixed-methods approach, data were collected through surveys, classroom observations, and experimental teaching involving fifth-grade students from several primary schools in Bac Giang province, Vietnam. Quantitative data were analyzed with descriptive statistics and comparative tests to identify gaps in students' skills, while qualitative insights were obtained through teacher interviews and classroom observations. The results reveal that many students struggle with problem recognition, reasoning, and solution presentation when solving ratio and percentage problems. The pedagogical interventions - designed based on Polya's four-step problem-solving framework and experiential learning activities - significantly improved students' analytical reasoning, logical thinking, and ability to transfer knowledge to new contexts. These findings highlight the importance of integrating problem-solving strategies into primary mathematics instruction and provide implications for curriculum developers, teachers, and educational policymakers.

KEYWORDS: Problem-solving skills, Mathematics education, Ratios and percentages, Primary school, Vietnam.

1. INTRODUCTION

Mathematics education is widely recognized as a cornerstone of general education because it equips learners with logical reasoning, analytical skills, and the ability to solve real-life problems. At the primary level, mathematics lays the foundation for lifelong learning by fostering core competencies such as problem-solving, communication, and creativity (Cai & Lester, 2010). Recent educational reforms have emphasized the importance of competency-based learning, shifting the focus from rote knowledge acquisition toward developing transferable skills that prepare students for complex and unpredictable contexts (Nguyen & Luong, 2022). Within this framework, problem-solving competence is not only a subject-specific outcome but also an essential component of 21st-century skills.

Among mathematical domains, ratios and percentages are particularly important because of their broad application in everyday life, ranging from interpreting statistical data to financial literacy. However, international research indicates that primary school students frequently encounter difficulties in mastering these concepts due to their abstract nature and the cognitive demands required for proportional reasoning (Kormos & Wisdom, 2021). Studies in China and other Asian contexts also reveal that many students rely on memorization and algorithmic approaches, leading to struggles when they are required to apply ratios and percentages in novel or practical situations (Sun et al., 2024). These findings highlight the urgent need to strengthen problem-solving skills through pedagogical approaches that integrate conceptual understanding with applied practice.

Vietnam's 2018 General Education Curriculum reflects this international trend by explicitly positioning problem-solving as a core competency in mathematics. For Grade 5 - the final year of primary school - ratios and percentages constitute a critical topic that synthesizes earlier arithmetic knowledge while preparing students for secondary mathematics. Yet, empirical evidence shows that Vietnamese classrooms still lean heavily on procedural teaching, focusing on worked examples and repetitive exercises rather than promoting higher-order reasoning (Vu, Hoang, & Le, 2022). As a result, many students remain unable to transfer their knowledge to solve word problems, analyze relationships between quantities, or explain their reasoning logically.

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Existing scholarship also underscores the challenges faced by rural and underserved schools. Limited resources, rigid pedagogical traditions, and students' lack of exposure to problem-based learning contribute to the gap between curriculum goals and actual classroom practice (Hussain, Wang, & Rahim, 2013; Passey et al., 2024). These constraints mirror global findings that disadvantaged learners often require more structured support to acquire abstract mathematical skills, making targeted interventions crucial for equity in education.

In response to these challenges, this study focuses on enhancing problem-solving skills among Grade 5 students when learning ratios and percentages. Drawing on Polya's (2004) four-step problem-solving model and experiential learning strategies, the research investigates both the current state of students' problem-solving skills and the effectiveness of specific pedagogical interventions. By employing surveys, classroom observations, and quasi-experimental teaching in Vietnamese primary schools, the study provides empirical evidence of how structured instructional designs can improve students' analytical reasoning, logical thinking, and ability to apply knowledge flexibly. The findings contribute not only to the local implementation of Vietnam's curriculum reform but also to broader discussions in international mathematics education on bridging the gap between procedural teaching and competency-based learning.

2. LITERATURE REVIEW

2.1 Problem-solving in primary mathematics

Problem-solving has been widely acknowledged as both a goal and a means of learning mathematics (Cai & Lester, 2010). For primary education, problem-solving serves as a crucial pathway to nurture reasoning, creativity, and the ability to transfer knowledge into new contexts. International studies emphasize that mathematical problem-solving competence encompasses more than computational accuracy; it requires the capacity to recognize a problem, devise strategies, and justify solutions (Niss & Højgaard, 2019). However, young learners often face difficulties in comprehending and representing word problems, especially those involving proportional reasoning such as ratios and percentages (Kormos & Wisdom, 2021; Sun et al., 2024).

In the Vietnamese context, ratios and percentages are introduced progressively throughout primary school and culminate in Grade 5 as a capstone topic before students transition to lower secondary education (Nguyen & Luong, 2022). Nevertheless, evidence suggests that many students can perform basic calculations but struggle to apply these concepts flexibly in solving real-life problems (Vu, Hoang, & Le, 2022). Similar challenges have been reported in other developing countries, where reliance on rote methods and limited use of problem-based learning hinder the development of problem-solving competence (Hussain, Wang, & Rahim, 2013). These findings underscore the necessity of pedagogical innovation to cultivate students' ability to engage meaningfully with mathematical problems.

2.2 Theoretical frameworks: Polya's model and skill formation

Polya's (2004) four-step problem-solving model: Understanding the problem, Devising a plan, Carrying out the plan, and Looking back, has been one of the most influential frameworks guiding mathematics education worldwide. Numerous empirical studies validate its effectiveness in promoting systematic reasoning and reflective thinking among students (Schoenfeld, 2013). For primary students, the structured nature of Polya's model provides scaffolding that helps them gradually acquire the ability to interpret mathematical problems, test different strategies, and evaluate their results.

In addition to Polya's model, contemporary perspectives on skill formation stress that problem-solving competence is not developed in isolation but through iterative practice, social interaction, and contextualized tasks (Passey, Peristeras, Magnisalis, & Mhlanga, 2024). Recent research also highlights the role of digital and experiential learning environments in strengthening learners' capacity to handle abstract mathematical concepts (Zacharis & Nikolopoulou, 2022). These frameworks collectively suggest that effective instruction should integrate systematic problem-solving processes with engaging, meaningful activities tailored to learners' developmental needs.

2.3 Research gap and objectives

While there is abundant theoretical work on problem-solving, empirical studies that focus specifically on ratios and percentages at the primary level remain limited, especially in developing contexts. Much of the existing literature has examined secondary or tertiary mathematics education, leaving the problem-solving difficulties of younger learners underexplored (Kormos & Wisdom, 2021; Sun et al., 2024). In Vietnam, although the 2018 General Education Curriculum places problem-solving at the center of mathematics instruction, classroom practices often emphasize procedural fluency at the expense of critical thinking and reasoning (Vu et al., 2022).

This gap calls for empirical research that not only diagnoses the current state of students' problem-solving skills but also tests practical interventions. Therefore, the present study aims to: (1) investigate Grade 5 students' problem-solving performance in ratios and percentages; (2) design and implement pedagogical interventions informed by Polya's problem-solving model; and (3) evaluate the impact of these interventions on students' skills. By addressing these objectives, the study contributes both theoretically, by

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applying established frameworks to an underserved context, and practically, by offering evidence-based recommendations for teachers and policymakers.

3. METHODS

3.1 Research design

This study employed a mixed-methods design that combined quantitative and qualitative approaches to provide a comprehensive understanding of Grade 5 students' problem-solving skills in ratios and percentages. The quantitative component included pre-tests and post-tests administered to experimental and control groups, enabling the evaluation of the effectiveness of pedagogical interventions. The qualitative component consisted of classroom observations, teacher interviews, and analysis of students' learning processes, which offered deeper insights into how instructional strategies influenced students' problem-solving competence. The study was conducted in line with the principles of educational action research, focusing on diagnosing current difficulties and testing targeted teaching measures in authentic classroom contexts.

3.2 Participants

The participants were Grade 5 students from primary schools in Bac Giang province, Vietnam. A total of two intact classes were selected: one served as the experimental group, and the other as the control group. The sample was chosen based on representativeness of average school conditions in semi-urban and rural contexts. Students' ages ranged from 10 to 11 years. In addition to students, several mathematics teachers were also involved in the study through interviews and participation in implementing the interventions. Informed consent was obtained from all participants, and the study adhered to ethical standards of educational research by ensuring anonymity and voluntary participation.

3.3 Instruments and procedures

The instruments included (1) a diagnostic survey and test of problem-solving skills in ratios and percentages, (2) a set of pedagogical interventions designed in line with Polya's four-step problem-solving framework, and (3) observation and interview protocols for qualitative data collection.

The interventions emphasized several key elements: reinforcing students' conceptual understanding of ratios and percentages, diversifying problem types and solution strategies, fostering problem-solving through practical and experiential tasks, and integrating technological tools such as calculators to support more complex calculations.

The procedure followed three stages. First, pre-tests were conducted to assess the baseline skills of both groups. Second, the experimental group received targeted instruction using the proposed interventions over a defined instructional period, while the control group continued with traditional teaching practices. Finally, post-tests were administered to both groups, accompanied by classroom observations and teacher interviews to triangulate the findings.

3.4 Data analysis

Quantitative data from the pre- and post-tests were analyzed using descriptive statistics (means, standard deviations) and inferential statistics (t-tests) to determine significant differences between the experimental and control groups. Effect sizes were also calculated to assess the magnitude of intervention impact. Qualitative data from classroom observations and teacher interviews were coded thematically, focusing on evidence of changes in students' reasoning, problem-solving strategies, and engagement. Triangulation of quantitative and qualitative data ensured the validity and reliability of findings. Missing data were handled using listwise deletion for cases with incomplete responses, and all analyses were conducted using SPSS.

4. RESULTS

4.1 Descriptive results on students' problem-solving skills

The diagnostic survey revealed that many Grade 5 students demonstrated limited competence in solving ratio and percentage problems. While a majority of students could correctly recall definitions and perform routine calculations, they often struggled with identifying the relationships between given and unknown quantities. For example, when asked to compute the ratio of boys to girls in a class or to convert a ratio into a percentage, students tended to rely on memorized formulas without demonstrating a clear understanding of the underlying concepts. Misinterpretations were particularly common in tasks requiring proportional reasoning, such as solving contextual word problems. These findings indicate that students' skills were uneven: procedural fluency was relatively stronger, while conceptual understanding and problem interpretation were considerably weaker.

4.2 Results of experimental intervention

To evaluate the effectiveness of the pedagogical measures, pre-test and post-test scores were compared between the experimental and control groups. Before the intervention, no statistically significant difference was found between the two groups in terms of

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their mean scores. After the intervention, however, the experimental group showed a marked improvement in problem-solving performance, particularly in the following areas:

1. Understanding problems – Students in the experimental group became more adept at identifying known and unknown quantities, and at representing problems using diagrams and verbal explanations.
2. Planning solutions – Students demonstrated greater flexibility in selecting solution strategies, such as using fractions, ratios, or percentages depending on the problem type.
3. Presenting solutions – Compared to the control group, the experimental group produced more systematic and accurate written solutions, with fewer computational and reasoning errors.
4. Reviewing and extending solutions – Students in the experimental group were more likely to check their answers and to propose alternative approaches, an ability rarely observed in the control group.

Statistical analysis (paired-sample t-tests) confirmed that the experimental group's post-test scores increased significantly compared to their pre-test scores, with a medium-to-large effect size, while the control group's progress was marginal. These results provide robust evidence that the proposed interventions based on Polya's problem-solving framework had a positive impact on students' problem-solving competence.

4.3 Qualitative insights from classroom observations and teacher interviews

Qualitative findings supported the quantitative results. Classroom observations revealed that students in the experimental group were more engaged and confident when solving ratio and percentage problems. They frequently collaborated in small groups, discussed different solution strategies, and used visual aids such as diagrams and percentage charts to support their reasoning. Teachers reported that students became more motivated to learn mathematics, as the integration of real-life contexts and experiential activities made problem-solving tasks more meaningful and less intimidating.

Teachers also emphasized that the structured problem-solving process - understanding the problem, planning, solving, and reviewing - helped students organize their thinking and avoid common errors. For instance, when solving problems involving percentages of a total, students initially confused "percentage of part" with "percentage of whole." After guided practice, they were able to differentiate these cases and apply the correct approach. Teachers highlighted that the interventions were feasible to implement within the existing curriculum and had the potential to be scaled up to other schools.

5. DISCUSSION

The findings of this study provide compelling evidence that targeted pedagogical interventions can significantly enhance Grade 5 students' problem-solving competence in ratios and percentages. The improvement observed in the experimental group - particularly in their ability to understand, plan, and review solutions - suggests that systematic instructional strategies based on Polya's framework are effective in overcoming common learning difficulties in primary mathematics. This result is consistent with prior research emphasizing that explicit scaffolding and structured approaches help young learners develop reasoning skills and move beyond procedural knowledge (Schoenfeld, 2013; Niss & Højgaard, 2019).

An important contribution of this study lies in confirming that conceptual reinforcement and the diversification of problem types are essential for sustainable learning. Many students initially relied on rote memorization and formula-based solving, but the interventions enabled them to build deeper conceptual understanding. This finding aligns with international evidence that mathematical literacy requires both procedural fluency and conceptual comprehension, particularly in proportional reasoning (Sun, Zhu, Zhou, & Yao, 2024). Moreover, the integration of experiential and real-life tasks increased students' engagement, echoing findings from Zacharis and Nikolopoulou (2022), who demonstrated that contextualized problem-solving activities foster motivation and persistence among primary learners.

Another key outcome was the positive reception from teachers. Observational and interview data revealed that the interventions not only improved students' performance but also enriched classroom dynamics, as students engaged in group discussions and shared diverse solution strategies. These results reinforce the argument that collaborative learning and the use of multiple representations are vital for developing problem-solving skills (Cai & Lester, 2010; Passey, Peristeras, Magnisalis, & Mhlanga, 2024). For Vietnamese primary schools, this implies that teacher professional development should emphasize instructional designs that balance conceptual instruction, problem-based learning, and experiential practice.

The findings also highlight important implications for curriculum implementation. Although the 2018 General Education Curriculum in Vietnam has formally recognized problem-solving as a central competency, classroom practices still tend to prioritize procedural exercises. This study shows that when teachers adopt structured interventions - reinforcing concepts, diversifying problems, and encouraging reflective thinking - students' competencies improve substantially. This echoes international calls for aligning policy aspirations with classroom practices by equipping teachers with evidence-based pedagogical strategies (Nguyen & Luong, 2022).

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Finally, the study contributes to the broader literature on equity in mathematics education. Students in rural and underserved contexts often face barriers to developing higher-order competencies due to limited resources and traditional teaching practices (Hussain, Wang, & Rahim, 2013). By demonstrating that low-cost, feasible interventions can yield significant learning gains, this research supports the argument that educational equity can be advanced through carefully designed classroom strategies. This resonates with Passey et al. (2024), who argued that digital and problem-based pedagogies are especially valuable in contexts with constrained resources.

6. CONCLUSION

This study demonstrated that structured pedagogical interventions grounded in Polya's problem-solving framework can substantially improve Grade 5 students' competence in solving ratio and percentage problems. The findings confirmed that while many students initially relied on memorization and procedural strategies, targeted instruction enabled them to strengthen conceptual understanding, diversify solution approaches, and engage more confidently with mathematical reasoning. The results provide evidence that problem-solving skills can be cultivated effectively at the primary level through systematic scaffolding, experiential learning, and the integration of real-life contexts.

By highlighting both the challenges and the potential of teaching problem-solving in Vietnamese primary schools, the study underscores the importance of aligning curriculum goals with classroom practices. Ultimately, equipping students with strong problem-solving competence in ratios and percentages not only enhances their mathematical literacy but also lays a foundation for lifelong learning and informed participation in everyday decision-making.

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